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# Examination of coastal vulnerability framings at multiple levels of governance using spatial MCDA approach

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ABSTRACT

The multidimensional impacts of climate change necessitate participation of large scale organizations in the management of vulnerability to climate change. Operating at multiple levels of governance, these organizations help manage the deleterious effects of changing climate for different sectors of human-environment systems. How they frame vulnerability, what influences their framings, why are their framings aligned or misaligned: while these are critical questions for managing vulnerability, they are often overlooked in the literature. By 'framing' we mean how actors understand and evaluate key factors of vulnerability. Through a case study in Bangladesh, we analyze how vulnerability is framed by the leading organizations across five sectors and three levels of governance. Drawing from key-informant interviews, we developed a spatial multi-criteria decision analysis (MCDA) approach and identified vulnerability hotspots. With few variations, our study reveals that the framings of vulnerability are mostly aligned across scale irrespective at which stakeholders are operating. Collectively, proximity to river/sea along with poverty, schooling, cropping intensity, soil salinity, and availability of multipurpose disaster shelters are identified as key determinants of vulnerability by all organizations. They prioritize infrastructural and agricultural development as basis for vulnerability management. We argue that similarity of the understanding of vulnerability across scale would facilitate adaptation decision-making process. However, less focus on socio-economic criteria can undermine the success of adaptation initiatives. While the findings of this study can assist the decision-makers of Bangladesh in coastal vulnerability management, the methodological approach should be useful to assess coastal vulnerability in other parts of the world as well.

## 1. Introduction

Operating at different levels of governance (e.g. national, regional, local), governmental and non-governmental organizations manage vulnerability to climate change by undertaking or enabling adaptation actions (Pahl-Wostl, 2009; Keskitalo, 2010; Termeer et al., 2010). The different ways that such organizations frame vulnerability – in other words, how they understand and evaluate vulnerability – are likely to affect how they interact in their efforts to ensure successful management of vulnerability across scales (Adger et al., 2005; O'Brien et al., 2004). Similarity in vulnerability framings of these organizations has the potential to increase the efficiency, effectiveness, equity, and legitimacy of vulnerability management, while significant misalignment can cause economic wastage, resource misallocation, maladaptation, governance failures, and fragmented development (Wilbanks and Kates, 1999; Gibson et al., 2000; O'Brien et al., 2004; Adger et al., 2005; Eakin and Luers, 2006; Pahl-Wostl, 2009; Engle, 2011). Similarity in framing can also ensure that diverse agencies pinpoint the same vulnerable areas and thus facilitate coordinated management. Contrarily, a misalignment in framing may suggest there is no agreement in what constitutes vulnerable areas, baffling decision-makers. By analyzing vulnerability framings, researchers can shed light on which criteria have been prioritized by what agencies and why, and thus which sector of engagement needs particular attention in future adaptation policy making.

'Vulnerability', in this study, is defined as the degree or extent to

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which a system is likely to be exposed and sensitive to a hazard, and the capacity of that system to adapt to the effects of climate impacts (Watts and Bohle, 1993; Cutter, 1996; Kasperson et al., 2005). By 'organization,' we refer to a set of actors and institutional arrangements with a common set of objectives, and who must interact across multiple action situations at different levels of activity (Polski and Ostrom, 2015). Formally, we define 'framing' as how an actor or an organization understands the structure and boundary of a system and prioritizes its functions (Leach et al., 2010). Despite significant discussion on the importance of analyzing vulnerability framings at different levels of governance, little effort has been made to date to capture such framings by actors engaged in managing vulnerability (e.g. Reidsma et al., 2009; Fekete et al., 2010; Carmenta et al., 2017). In this paper, we present an analysis of how different organizations, at different levels of government, frame vulnerability in the context of coastal areas in Bangladesh. We adopted the diagnostic framing approach (Snow and Benford, 1988) in which the stakeholders are involved in the identification and attribution of key factors of vulnerability.

Located only a few meters above mean sea level, the south-central coastal Bangladesh is experiencing the adverse impacts of climate change in the form of recurrent flooding, increased frequency of tropical cyclones, higher tidal surges, wider tidal fluctuations, and penetration of salt water inland. Downscaled analyses of climate impacts indicate that a large part of this area will likely to be flooded by next three decades due to the changing climate (Karim and Mimura, 2008; Bhuiyan and Dutta, 2012; Dasgupta et al., 2014). The potential negative consequences of flooding have persuaded the government of Bangladesh to adopt an inclusive approach in order to manage vulnerabilities in the coastal systems. The government has distributed the responsibility for climate change response across multiple organizations with mandates of different scopes, and has fostered the participation of non-governmental organizations (NGOs) in reducing climate change vulnerability. These organizations operate at different levels of governance with variable authority. As such, the national government has taken a multilevel governance approach by ensuring participation of a range of organizations operating at different levels of jurisdictional and/or corresponding spatial scale in formulating and implementing activities to reduce vulnerability. Following Termeer et al. (2010), we define 'multilevel governance' as the decision-making and decision implementation that involves multiple actors at multiple levels of governance and that takes place across multiple jurisdictions and sectors. In this multilevel governance context, we would expect that if the organizations involved have similar framings of vulnerability, they would have similar priorities for action and make decisions in a synergistic and complementary fashion. However, this assumption may not always hold true.

Multilevel vulnerability management has primarily been analyzed in two ways: *multilevel interactions* and *multilevel assessment*. Studies of *multilevel interactions* are concerned with exploring the interactions among stakeholders operating at different levels of governance. Such interactions, often of two types-vertical and horizontal– can subdue the consequences of scale mismatch, multiple interpretation, and vulnerability tradeoffs (Young, 2002; Cash et al., 2006; Janssen and Anderies, 2007). The empirical evidence suggests that multilevel interactions are highly contextualized in nature and influenced by the governance system. For instance, a centralized system in England develops well-integrated and efficient vertical and horizontal interactions among the organizations involved in vulnerability management (Keskitalo, 2010), while under a similar centralized system in Senegal, limited vertical coordination undermines the local level efforts to address vulnerability (Vedeld et al., 2016). On the other hand, *multilevel vulnerability assessments* are concerned with representing the differential manifestation of vulnerability across spatial scales. These assessments mostly focus on units of analysis at different levels of spatial scales. The determinants of vulnerability may be treated equally at all scales, or analyses may adopt expert judgment to weigh determinants differently according to different processes at play across various decision levels. O'Brien et al. (2004), Fekete et al. (2010) and Mclaughlin and Cooper (2010) argued that important local variations are masked by simplification at national scale and thus analyses need to be conducted at all possible levels before an adaptation decision is made. The selection of determinants is contentious; some scholars support using the same vulnerability determinants irrespective of scale it is being analyzed (e.g. O'Brien et al., 2004; Balica et al., 2009), while others found that the determinants vary across different levels with implications for investment and development (e.g. Birkmann, 2007; Antwi-Agyei et al., 2017). Overall, these efforts explore the linkages among organizations and other stakeholders at multiple levels of governance and capture the vulnerability manifestation across spatial scale. Yet, the questions of how the multilevel organizations frame vulnerability and why there is a coherence or difference in their framing are still under-researched.

In order to address the climate change vulnerability more effectively, the government of Bangladesh formulated the National Adaptation Program of Action (NAPA), Bangladesh Climate Change Strategy and Action Plan (BCCSAP), and National Plan for Disaster Management (NPDM). In their effort to implement the NAPA, the government focuses on six sectors of engagement: agriculture, forestry, water, livelihood, industry and infrastructure, and policy and institutions (NAPA, 2009). Although around 40 ministries and their associated departments and autonomous organizations are working in these sectors to reduce climate induced vulnerability, there are only a few organizations and agencies with key roles in implementation of an action plan. For instance, in the hydrology or water resources sector, four organizations are actively engaged under the Ministry of Water Resources, and among them Bangladesh Water Development Board is the dominant organization in terms of resources, work scope, and influence (see Table 1). Furthermore, along with the government organizations, non-government organizations (NGOs) play active roles in vulnerability reduction efforts, particularly in socio-economic sectors (Khan and Rahman, 2007a,b; Islam and Walkerden, 2015). These organizations are mostly hierarchical and follow jurisdictional scale (i.e. national, division, district, sub-district) in governance (Rahman and Tosun, 2018). In the development of climate policies, plans, and actions they actively contribute through baseline information collection, vulnerability assessments, synthesis of information, and decision making (Shaw et al., 2013).

To date, there have been a few efforts to understand the role of organizations in climate vulnerability management in coastal Bangladesh (e.g. Matin and Taher, 2001; Thomalla et al., 2005; Khan and Rahman, 2007a,b; Ikeda, 2009; Islam and Walkerden, 2015). Focusing mostly on NGOs, these studies indicated that NGOs play crucial roles in the reduction of natural disaster vulnerability through various social and economic activities but often criticized for concentrating more on short-term emergency events for financial benefits and ignore long-term vulnerability reduction measures. Despite these studies, it is less-understood that how the government and non-government organizations frame vulnerability or what influences their framings. Alignment in framings would potentially limit the resource wastage, avoid episodic development initiatives, and assist in coordinating investment decisions, and adaptation planning; the misalignment would do otherwise.

This lacuna in the research leads us to ask the following questions: How do sectoral organizations operating at different levels of governance frame vulnerability? What elements do such organizations prioritize as vulnerability determinants? What factors might explain any observed alignment or mismatch in their framings? We tackle these questions by conducting a primary research on the major actors across sectors (i.e. hydrological, infrastructural, agricultural, forestry, socio-economic) and levels of governance (i.e. national, district, sub-district). We select the leading government organizations in hydrology, infrastructure, agriculture, and forestry sector which are involved in the vulnerability management in the south-central coastal region of

**Table 1**
Sectoral (government) organizations involved in managing vulnerability to climate change management in coastal areas of Bangladesh.

| Sector | Key Ministry | Associated Organizations | Leading Organization | Key Actions |
|---|---|---|---|---|
| Agriculture | Ministry of Agriculture | I. Department of Agricultural Extension<br>II. Bangladesh Agricultural Development Corporation<br>III. Bangladesh Agricultural Research Council<br>IV. Bangladesh Agricultural Research Institute<br>V. Bangladesh Rice Research Institute<br>VI. Bangladesh Jute Research Institute<br>VII. Bangladesh Institute of Nuclear Agriculture<br>VIII. Agricultural Information Services<br>IX. National Agricultural Training Academy<br>X. Department of Agricultural Marketing<br>XI. Seed Certification Agency<br>XII. Soil Resource Development Institute | Department of Agricultural Extension (DAE) | - Providing need based extension services to farmers.<br>- Enabling farmers to optimize resources to promote sustainable agricultural practices and socio-economic growth.<br>- Assisting the farmers to increase agricultural productivity and adopt new technology. |
| Hydrology | Ministry of Water Resources | I. Bangladesh Water Development Board<br>II. River Research Institute<br>III. Directorate of Bangladesh Haor and Wetland Development<br>IV. Water Resources Planning Organization | Bangladesh Water Development Board (BWDB) | - Development and management water resource projects through embankments, levees, and sluice gates.<br>- Management and mitigation of river bank erosion.<br>- Promoting food production through surface water irrigation.<br>- Ensuring stakeholder participation in environment friendly development initiatives. |
| Infrastructures | Ministry of Local Government, Rural Development & Cooperatives | I. Local Government Engineering Department<br>II. City Corporations<br>III. National Institute of Local Government<br>IV. Department of Public Health Engineering | Local Government Engineering Department (LGED) | - Improving accessibility of rural growth centers.<br>- Construction of embankments.<br>- Construction of disaster shelters, tree plantation on embankments.<br>- Urban infrastructure development.<br>- Providing technical support to district, sub-district, and union administrations. |
| Forestry | Ministry of Environment & Forests | I. Bangladesh Forest Department<br>II. Department of Environment<br>III. Bangladesh Forest Research Institute<br>IV. Bangladesh Forest Development Corporation | Bangladesh Forest Department (FD) | - Conservation and sustainable management of forest, wildlife, and biodiversity.<br>- Increasing land stability and climate resiliency of ecosystem.<br>- Expanding social forestry and ensuring stakeholder participation.<br>- Increasing forest cover through afforestation and reforestation. |

(*continued on next page*)

**Table 1** (*continued*)

| Sector | | Key Ministry | Associated Organizations | Leading Organization | Key Actions |
|---|---|---|---|---|---|
| Socio-economy | Ministry of: Social Welfare, Disaster Management and Relief, Finance, Health & Family Welfare | I. Local Non-Government Organizations (NGOs)<br>II. International NGOs<br>III. Other relevant government organizations | Local NGOs | - Microfinance<br>- Disaster management<br>- Education provision<br>- Community empowerment<br>- Human rights and justice<br>- Eliminating poverty<br>- Health and nutrition | |

Bangladesh as major actors (Table 1). Because of their active participation in vulnerability management, we also included the leading NGOs, who primarily attend the socio-economic sectors. Most of these NGOs work at two levels: national and local. We identified 'leading' organizations on the basis of the scope of work, resources, funding, and reputation. We develop an indicator-based composite vulnerability index and identified vulnerability hotspots using a spatial multi-criteria decision analysis (MCDA) approach-an approach that is concerned with solving spatial decision and planning problems involving multiple criteria, for each of the leading organizations at each level of governance. Because vulnerability hotspots are those areas where there is strong agreement over vulnerability, their identification can assist the decision makers in narrowing resource investment and preventing wastage. Lack of coincidence in the prioritization of vulnerable areas among the organizations would indicate a lack of underlying agreement on the determinants of vulnerability and potentially a need for further investigation on the source of such disagreement.

## 2. Study area

The south-central coast of Bangladesh is home to more than eight million people. This 9000 $km^2$ area is divided into five contiguous districts and 32 sub-districts (Fig. 1). In this paper, we consider sub-district as unit of analysis because of the data availability at that scale, and to better capture dynamics of vulnerability. The area regularly encounters climate-induced events such as floods, tropical cyclones, and high tidal variation. Unlike southwest or southeast coastal plain, the south-central coast is not protected by mangrove forest or hills, and hence is exposed to extreme events. Two types of floods usually occur in this region: river floods and tidal floods. River floods occur during monsoon and post-monsoon period due to spilling of river waters. The tidal floods occur when high tide or surge inundates large tract of lands. Following the Dutch model of polders, the government built 44 polders (embanked low lying areas) during 1960s–1970s to protect the inhabitants from cyclone and tidal surge and to ensure food security by expanding agricultural lands. However, the system is still vulnerable to higher-intensity floods and cyclones due to embankment debility, and the population's mistrust in warning signs, fear of household larceny (affecting their willingness to evacuate), and obliviousness to the impacts of previous events (Saari and Rahman, 2003; Roy et al., 2015; Garai, 2017; Ishtiaque et al., 2017). Dasgupta et al. (2014) found that under the changing climate this region will encounter approximately 27 cm rise in sea level per year and as a result all the polders will be overtopped by 2050 unless the government invests more than $800 million to heighten the embankments. Furthermore, they estimated that the damage of the tropical cyclones would be more intense, potentially costing more than $2 billion by 2050.

## 3. Materials and methods

In order to examine the coastal vulnerability framings by the leading organizations operating at different sectors of engagement and levels of governance, we followed several steps. First, we developed an indicator-based composite vulnerability index by consulting with key-informants from the leading organizations and by putting relative weights to the indicators using MCDA approach (i.e. analytical network process). Second, we mapped the results of each organization's framing of vulnerability, and identified the vulnerability hotspots for each of the leading organizations and for each level of governance. Third, we analyzed the variation in the relative importance of specific vulnerability criteria across the leading organizations. This three step approach can be used to assess coastal vulnerability in any part of the world and thus serve as a generalizable approach to elicit the framings of distinct organizations that are involved in collaborative adaptation governance in a specific coastal area. It is important to note that this methodological approach requires a large set of proxy indicators for

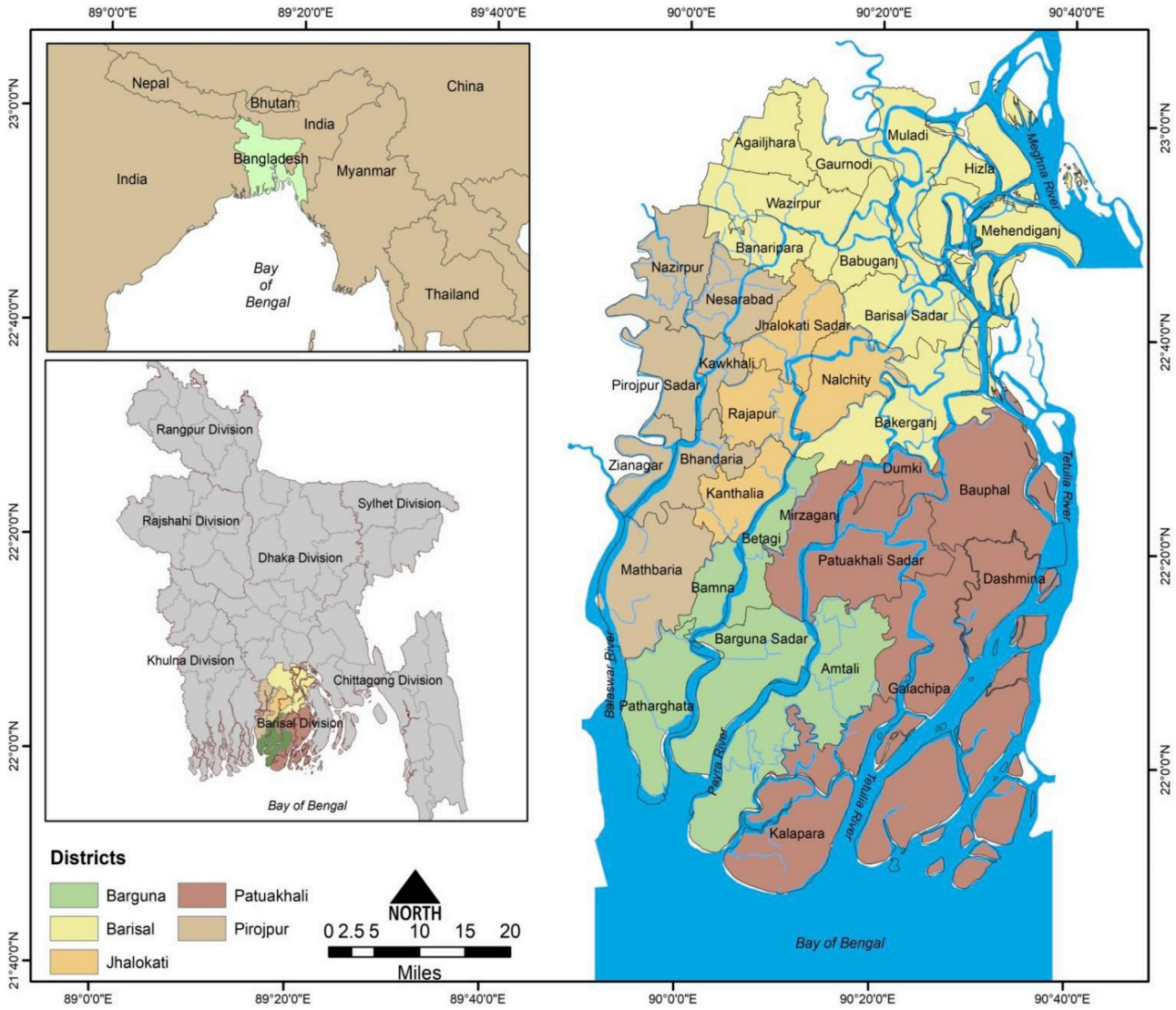


**Fig. 1.** Location of the study area- 32 sub-districts under five districts in Barisal Division.

vulnerability, extensive interviews with decision-makers, and unbiased identification of vulnerable areas. As such, availability of data, access to decision-makers, and caution for interviewer biasness would be imperative to adopt this approach.

### 3.1. Development of vulnerability index

#### 3.1.1. Vulnerability indicators

Indicator-based vulnerability assessment requires the selection of proxy variables for biophysical and socio-economic components (Moss et al., 2001; Cutter et al., 2003) thought to represent the three core aspects of vulnerability of a system: exposure, sensitivity, and adaptive capacity (Eakin and Bojórquez-Tapia, 2008). Exposure indicators mostly represent the physical risk of the region. Sensitivity indicators reflect the dependence of actors on hazard-sensitive activities and patterns of resource use. Adaptive capacity indicators measure the access to entitlements and resources that can be mobilized to cope with and adapt to climatic threats: health status, wealth, information access, resource stocks and access. Note that interpretations of these indicators are context specific. For instance, Gerlitz et al. (2017) found that indebtedness in Hindu-Kush Himalayan region increases the sensitivity through intensifying the financial tension during times of emergencies. Lemos et al. (2016), however, argued that access to loans in Northeast Brazil increases adaptive capacity. As such, the indicators need to be interpreted in the context of study area (in this case, coastal Bangladesh) and informed by prior research that associates system variables to vulnerability outcomes in the area.

Based on a literature review, we identified 27 indicators of vulnerability and categorized them under seven major dimensions. These indicators have been widely used in vulnerability research as proxy variables for determining vulnerability. They served as first-level criteria for structuring the vulnerability assessment: social, economic, natural, agriculture, land use, infrastructure, and household characteristics (see Supplementary Table 1). Data for each sub-criterion (or indicator), collected from census reports and district statistics, was aggregated at the sub-district level.

#### 3.1.2. Data standardization

There are several ways for data standardization (see Yoon, 2012; Nguyen et al., 2016). We used a *min-max rescaling transformation* to transform the diverse measurement scales and units of the sub-criteria into a uniform measurement scale with a range between zero and one (Cutter et al., 2010; Yoon, 2012; Ahsan and Warner, 2014). In this study, if the higher value of a sub-criterion represents higher vulnerability (e.g. poverty rate), the standardization was been done as following:

$$s_i = \begin{cases} 0 & if \ \ v_i = v_{min} \\ \frac{v_i - v_{min}}{v_{max} - v_{min}} & if \ \ v_{min} < v_i < v_{max} \\ 1 & if \ \ v_i = v_{max} \end{cases}$$

On the other hand, if the lower value of a sub-criterion represents higher vulnerability (e.g. elevation), it is standardized as follows:

$$s_i = \begin{cases} 0 & if \ \ v_i = v_{min} \\ \frac{v_{max} - v_i}{v_{max} - v_{min}} & if \ \ v_{min} < v_i < v_{max} \\ 1 & if \ \ v_i = v_{max} \end{cases}$$

#### 3.1.3. Key-informant interviews

We conducted key-informant interviews in the three offices (i.e. national, district, and sub-district office) of each leading government organization and two offices (i.e. national, local) of two NGOs: BRAC and Sangram. We prepared a semi-structured questionnaire and interviewed 25 key informants who had substantial knowledge on that organization's activities and held enough authority to comment as a representative of that organization. Interviews lasted approximately an hour, in which the interviewees provided a detailed description of their organizational activities as well as evaluated specific vulnerability criteria as part of a process of eliciting their vulnerability framings. The relative importance of the pre-identified vulnerability criteria for the interviewee was interpreted as an indication of how they framed primary factors influencing on vulnerability in the region. Each interviewee was asked to create a network structure: a structure that related specific vulnerability criterion to other criterion within an overall structure that presented vulnerability as a product of a series of first-level criteria (i.e., social, economic, natural, agriculture, land use, infrastructure, and household characteristics) (Fig. 2). We made sure that the creation of network structure was not influenced by interviewer bias.

Later, the interviewees perform a pairwise comparison of first-level criteria using Saaty's scale (Saaty, 1987) (Table 2). This process involves each interviewee deciding which of two criteria (e.g., “social” vs. “economic”) is more important as a vulnerability determinant, and then *how much* more important. To reduce interviewee fatigue, we limited the pairwise comparisons to the first-level criteria, and instead asked them to ordinally rank the sub criteria within each first-level category (e.g., rank the sub criteria related to “social” and then the sub-criteria related to “natural” etc.). The sub-criteria ranking was done following an ascending order of significance in determining vulnerability (Bausch et al., 2014). Note that, the interview could be long and exhaustive for the interviewees if they have to create the network structure or do the pairwise comparison alone. Interviewer should provide a succinct detail of how the network structure functions toward vulnerability and may guide the interviewee in the process of network structure creation and pairwise comparison, but at the same time the interviewer needs to ensure that the process is devoid of interviewer-biasness.

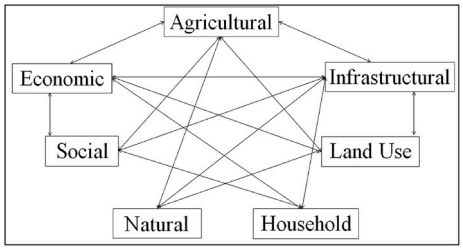


**Fig. 2.** A network structure of vulnerability criteria created by the district level DAE official. Each interviewee created a separate network structure based on their prior knowledge and experience.

#### 3.1.4. Analytical network process (ANP)

The criteria weighting for each office of the organizations was determined using the ANP process. Once the pairwise comparison was completed, the priority weight vector was computed using Super decision software (Liu et al., 2003). To be acceptable, the weighting of all criteria needed to obtain a consistency ratio of less than 0.1 (Saaty, 1990). The criteria were put into a supermatrix-a form of partitioned matrix comprising of several block matrices, to represent their interrelationships (see Fig. 3). Each block matrix contained the priority weight vectors of the elements and represents the influence (or importance) of the elements over one another. Later, this initial supermatrix was modified to a weighted supermatrix so that each of the columns sums to unity (Saaty, 2006).

However, as all the criteria are part of a network, a criterion can indirectly influence a third criterion through a second criterion. To capture this transmission of influence along all possible paths of supermatrix, a limit matrix is required. The limit matrix was processed by raising the entire supermatrix to powers until convergence so that all columns are identical. The limit matrix provides the final weight to the criteria and the sum of all the criteria is one.

#### 3.1.5. Sub-criteria weights

During the interview process the interviewees were asked to rank the sub-criteria based on their importance in evaluating vulnerability. The rank scale was in ascending order meaning 1 is the most important, 2 is the second most importance, and so on. However, this ordinal scale for sub-criteria weights cannot be directly compared to the criteria weights without transformation (Bausch et al., 2014). In this study, using *rank-order centroid* method the ordinal scale is transformed to weights ($w_i$) in a scale with ratio properties (Noh and Lee, 2003):

$$w_i = \frac{1}{n} \sum_{k=i}^{n} \frac{1}{k} \tag{1}$$

where, $i$ is the index variable, $n$ is the number of variables, $k$ is the rank of variable determined by the interviewee. After calculating the weights for all sub-criteria, the weights were normalized with respect to the criteria weights. To illustrate, hydrological organization gave the weight of 0.225 to the agricultural criterion. The weights of the agricultural sub-criteria were then standardized, so that the sum of the sub-criteria weights equaled to the criteria weight (0.225).

### 3.2. Vulnerability mapping and hotspots

#### 3.2.1. Vulnerability score and categories

Once the data were standardized and relative weights of sub-criteria were determined, the final vulnerability score for each location was calculated as:

$$V_i = \sum_{i=1}^{n} s_i w_i \tag{2}$$

where, $V_i$ is the final vulnerability score, $s_i$ is the standardized data score, and $w_i$ is the sub-criteria weights. Based on Equation (2) vulnerability ranges from 0 to 1, where 0 represents the least vulnerability and 1 denotes the most vulnerable. After calculating vulnerability for all sub-districts, a vulnerability map was produced for each organization and for each level. The final vulnerability index was divided into five categories:{*VL* (very low), *L* (low), *M* (moderate), *H* (high), *VH* (very high)} based on *Weber-Fechner Law* (Weber, 1834; Fechner, 1860; Lootsma, 1999; Bojórquez-Tapia et al., 2009). The Weber-Fechner Law states that perception is proportional to increase of stimulus which is noticeable only when it increases by a constant percentage, known as ‘just noticeable difference’ (For details, see Bojórquez-Tapia et al., 2009; Reichl et al., 2010).

In this study, the category cuts, $c_v$, are computed with respect to the best state or the lowest vulnerability score, $c^-$:

**Table 2**
Scale of relative importance (Saaty, 1987).

| Intensity of importance | Definition | Explanation |
|---|---|---|
| 1 | Equal importance | Two criteria contributes equally |
| 3 | Moderate importance | Experience and judgment slightly favor one over another |
| 5 | Strong importance | Experience and judgment strongly favor one over another |
| 7 | Very strong importance | Activity is strongly favored and its dominance is demonstrated in practice |
| 9 | Extreme importance | Importance of one over another affirmed on the highest possible order |
| 2, 4, 6, 8 | Intermediate values | Used to represent compromise between the priorities listed above |

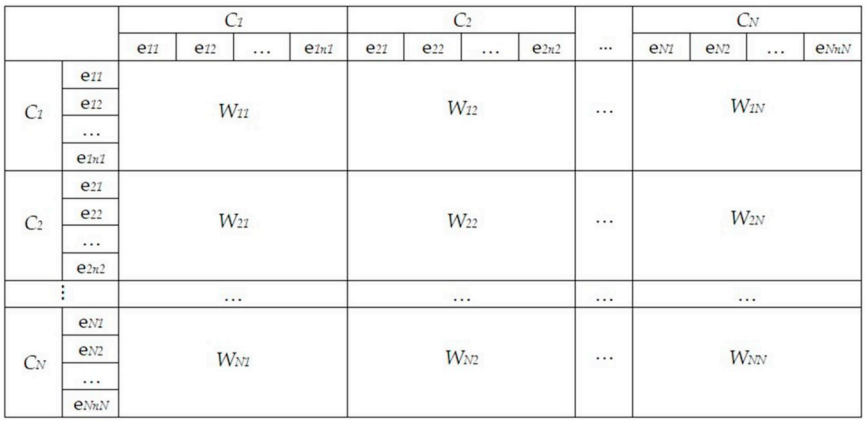


**Fig. 3.** A general form of supermatrix. Here, *C* represents components (or criteria), *e* represents element (or sub-criteria), and *W* represents relative weights obtained through pairwise comparison.

$$c_v = c_0(1 + r)^v + c^-$$

where, $v$ is the category cut value as *VL* equals to 1, *L* equals to 2, and so on; $c^-$ represents the best state of stimulus; (1 + r) is the progression factor representing the relationship between the stimulus and perceived intensity; $c_0$ is the initial stimulus representing the smallest detectable level of a stimulus and can be calculated as follows:

$$c_0 = \frac{c_n}{(1 + r)^n}$$

where, $n$ is the number of vulnerability categories; $c_n$ is the difference between the best and worst state of the stimulus. For each category cut, we tested different progression factors ranging from 1 to 2, and found 1.25 progression factor as the most suitable for this analysis (For details, see Bojórquez-Tapia et al., 2009). We suggest trialing different progression factors and further consulting with the interviewees to obtain a specific progression factor. If multiple progression factors are selected by the interviewees, arithmetic mean could be considered for analysis.

#### 3.2.2. Vulnerability hotspot identification

To analyze the vulnerability hotspots, both global and local clustering techniques were employed. We relied on two indices of spatial clustering. Global spatial autocorrelation was assessed using Moran's *I*. Ranging from −1 to +1, this index indicates spatial dispersion (−1) or aggregation (+1). On the other hand, the local clustering was identified using Getis-Ord *Gi** (Getis and Ord, 1992) to determine local hotspot. The spatial weight was based on a queen case contiguity rule-based spatial weight matrix for both indices.

### 3.3. Analysis of variation in criteria weighting

In order to analyze the variation of criteria weightings among the organizations, determined using the information from the key-informant interview and ANP processes, we adopted one-way analysis of variance (ANOVA). ANOVA reveals statistically significant differences between the means of two or more independent groups or samples. We conducted the ANOVA test and associated post-hoc test for each organization type and level of governance.

## 4. Results

The coastal vulnerability maps indicate significant homogeneity in the framings of vulnerability by the different organizations, though some variations can be observed (Fig. 4). It is the result of weighting of different criteria by the key respondents (Fig. 5). Collectively, the representatives of the different organizations concur that the eastern part of the study area is highly vulnerable while the central part is the least vulnerable (Fig. 6). According to our analysis, vulnerability of Muladi, Mehendiganj, Gaurnodi, Babuganj, Hizla, and Barisal Sadar sub-districts (under *Barisal* district), in the northeast part, is considered particularly high given their proximity to the *Meghna River* (*E*), greater number of earthen houses (*S*), high poverty rate (*S*), low amount of net cultivated and vegetated area (*S*), lack of irrigation facilities (*AC*), and existence of fewer flood shelters (*AC*). Some organizations' framings also identified the southeastern sub-districts as highly vulnerable. In particular, Galachipa and Bauphal sub-districts (under *Patuakhali*) are relatively more vulnerable because of their low elevation (*E*), adjacency to the *Tetulia River* and the *Bay of Bengal* (*E*), a high number of earthen houses with no electricity (*S, AC*), and less net cultivated area with high soil salinity (*S, AC*). In all of their framings, organization representatives designated the least vulnerable areas as the Betagi, Barguna Sadar (under *Barguna* districts), Kathalia (under *Jhalokati* districts), and Mirzaganj sub-districts (under *Patuakhali* districts). This designation resulted from relatively greater distance from major rivers and the sea (*E*), a low poverty rate (*S*), a greater number of schools and colleges (*AC*), high cropping intensity (*AC*), and low soil salinity (*AC*). Geographically, the entire western part of study area is classified as moderate to low vulnerable to flood as it is located away from large water bodies. However, Zianagar sub-district (under *Pirojpur*) depicts high vulnerability compared to its adjacent areas because of significantly low literacy rate (*AC*), few flood shelters and educational institutions (*AC*), lack of fertile soil and farming equipment (*S, AC*), and

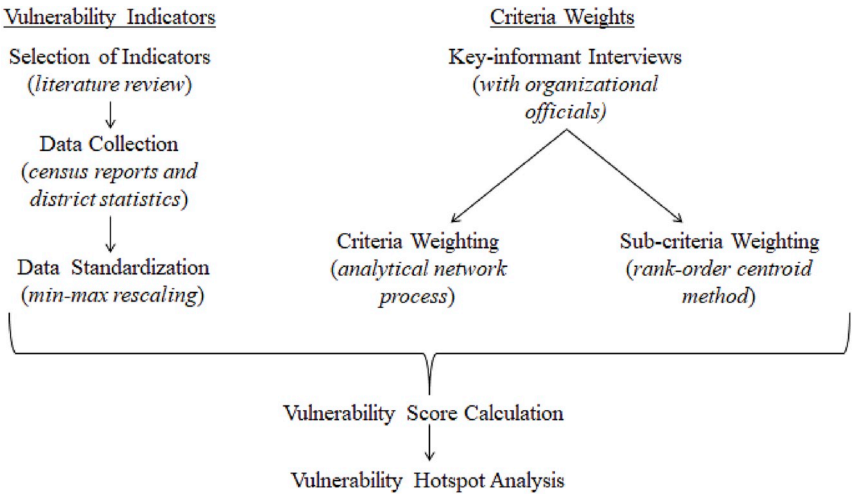


**Fig. 4.** Workflow diagram of vulnerability analysis.

proximity to the *Balaswar River* (*E*). Overall, poverty, education, means of livelihoods, household structure, and proximity to rivers or sea are playing key roles in determining vulnerability in the framings of all the organizations consulted.

Although the vulnerability framings of the leading organizations are mostly aligned, they contain some variations. Particularly, the framing of NGOs differs significantly with most of the government organizations. In the following sections, we discuss how vulnerability framings vary across the levels of governance and sectors based on each criterion. Note that the differences in prioritization for each criterion do not

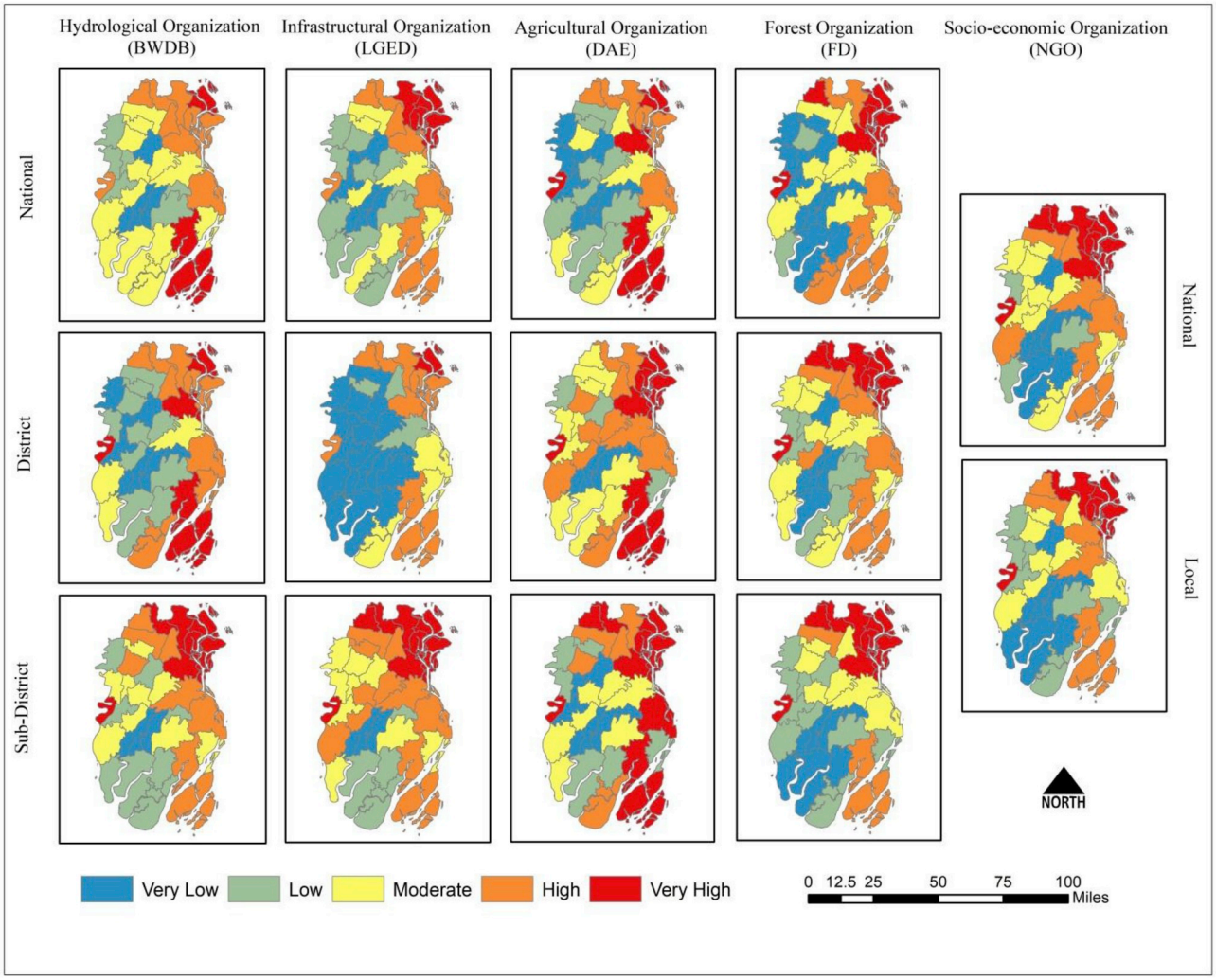


**Fig. 5.** Vulnerability framings by the studied organizations at each sector and level.

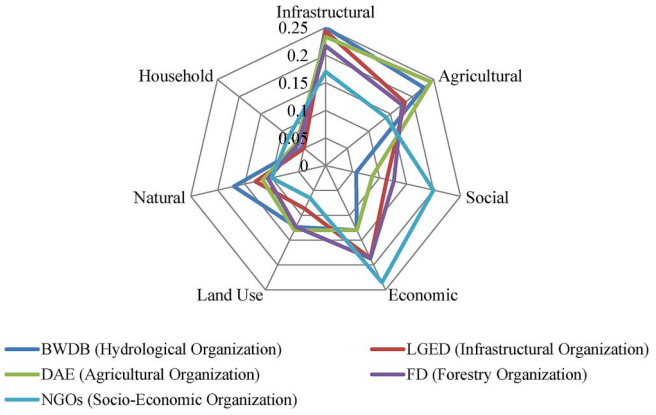


**Fig. 6.** Comparative criteria weighting by the studied organizations.

explicitly represent discrepancies in the overall vulnerability framings of these organizations, rather, it is the combinations of weighting of criteria and sub-criteria that determine the overall framing.

### 4.1. Determinants of vulnerability

#### 4.1.1. Infrastructure

The studied organizations acknowledge the significance of infrastructure in this hazard prone area and recommended that infrastructure should remain as one of the topmost priorities in future planning and policy formulation. They consider that both flood shelters and educational institutions are important during floods. Construction of schools and colleges in flood prone areas, while at first may seem counterintuitive and perhaps *maladaptive* (by increasing exposure of key services to flooding), in practice can serve two purposes: the provision of education (enhancing capacity over long-term) and supporting evacuees during emergency (reducing exposure at times of flood). While these institutions are customarily built by LGED, other organizations recognized the importance of such infrastructure in managing flood-induced vulnerability. The representative of the sub-district-level of DAE, for example, comments that without embankments agriculture would be nearly impossible in this region because of high soil salinity and tidal fluctuations, and thus weighted infrastructure higher than agriculture. As such, the ANOVA test did not find any significant differences between the infrastructural criteria weights by BWDB, LGED, DAE, and FD (Table 3).

However, the NGOs' prioritization differs significantly with several organizations, as they think disaster shelters are certainly required but that “social awareness” of disasters should also receive priority. They found that in many instances the local people are reluctant to take refuge in disaster shelters because of the mistrust in early warnings and notices, fear of theft of their belongings and loss of memory of the impacts of previous events (Garai, 2017; Ishtiaque et al., 2017). For instance, in our study area, during cyclone *Mora,* Bangladesh Meteorological Department raised the warning signal to 8 (great danger) in fear of strong winds and storm surge, but the cyclone made landfall in south-eastern Bangladesh and part of Myanmar, leaving the study area unaffected. The NGOs said, the ‘government wanted us to help evacuate the vulnerable people under the warning signal 8, but the local people laughed at and ignore the evacuation process indicating the clear and sunny sky.’ This is further complicated by the narrative of the NGOs, who point that the study area already has a good number of educational institutions that can serve as disaster shelters and the emphasis should be on disaster awareness among local people. Overall, the organizations agreed that infrastructure is a key criterion for coastal vulnerability management but the NGOs additionally stressed on the inclusion of social aspects, capacity building, to infrastructural solutions.

#### 4.1.2. Agriculture

Agricultural criteria are also ranked high by most of the organizations, possibly reflecting the extreme vulnerability of net cultivated area, intensely cropped areas, and irrigation facilities to floods. Most of the organization working in the rural area prioritize sustaining agriculture in their long-term planning as agriculture encompasses a major source of livelihoods. Historically, safeguarding and expanding the agricultural lands was one of the major objectives of BWDB and DAE. In all level of governance, these two organizations emphasized the importance of agriculture as source of livelihoods. Furthermore, despite their operational differences, the national and district level offices of LGED and FD acknowledged the importance of agricultural criteria. The LGED official commented, ‘you will find agricultural lands almost everywhere in this region. Before hitting the settlements, floods damage the agricultural lands, and destroy the economic base of the agricultural households, and thus make them vulnerable.’ However, the national and sub-district level FD, sub-district level LGED, and the NGOs conceded that although rural economy mostly relies on agriculture, the overall economy should be prioritized. More than 55% of employed populations in this region are engaged in non-agriculture related work and the overall economy has started to shift from agriculture to service activities; around 40% people work in the service sector (LFS, 2018). As such, unlike BWDB and DAE, other organizations are mostly in favor of prioritizing agriculture equal to or less than overall economy. Such differences in their prioritization feed into the differences in their overall vulnerability framings (Table 4). In sum, some organizations prioritize agricultural criteria because of their operational objectives, but other organizations put similar or lesser emphasis than economic criteria. Difference in vulnerability framing point us to the likelihoods that what may be perceived as climate change adaptation may actually be underpinned by different understanding and unspoken assumption held by the stakeholders involved.

#### 4.1.3. Social

Social criteria are less emphasized by the leading government organizations. This is not surprising. For example, BWDB, LGED, and DAE emphasized social aspects less compared to other criteria. This is partly due to their operational objectives and long term planning goals, which do not address social criteria directly. Notably, LGED is actively involved in reducing the poverty rate and increasing the education rate by constructing market centers and multipurpose emergency shelters, and connecting remote areas through roadways. Also, DAE is engaged

**Table 3**
Differences in mean value between organizations in terms of infrastructural criteria weighting.

| Organizations | BWDB | LGED | DAE | FD | NGOs |
|---|---|---|---|---|---|
| BWDB | | 0.007 | 0.017 | 0.033 | 0.080** |
| LGED | | | 0.010 | 0.027 | 0.073* |
| DAE | | | | 0.017 | 0.063* |
| FD | | | | | 0.047 |
| ANOVA Diagnostic | *F*-statistics: 6.554** | | | | |
| Significance | *p*-value: ‘***’ < 0.001, ‘**’ < 0.01, ‘*’ < 0.05 | | | | |

**Table 4**
Differences in mean value between organizations in terms of agricultural criteria weighting.

| Organizations | BWDB | LGED | DAE | FD | NGOs |
|---|---|---|---|---|---|
| BWDB | | 0.043 | −0.017 | 0.050 | −0.087* |
| LGED | | | −0.060* | 0.007 | 0.043 |
| DAE | | | | 0.067* | 0.103** |
| FD | | | | | 0.037 |
| ANOVA Diagnostic | *F*-statistics: 9.159** | | | | |
| Significance | *p*-value: ‘***’ < 0.001, ‘**’ < 0.01, ‘*’ < 0.05 | | | | |

in poverty reduction by intensifying crop production, distributing climate resilient crop varieties, and educating farmers. Nevertheless, while these organizations think that social criteria are crucial for adaptive capacity development, they believe that focus should be given to strengthening infrastructures. For instance, the district level BWDB said: 'certainly, social criteria are important, but if you don't have infrastructural support or a good base of agriculture for your economy, it really doesn't matter whether you have high education or low population density.' While they might be true to some extent, such biasness towards infrastructure based understanding is not new in vulnerability literature.

Social criteria are ranked highly by FD and NGOs. The operational objectives of NGOs primarily include poverty reduction, increase of education, health and demographic development etc. In that respect, their prioritization of social criteria reflects their operational interest. Grounded on social science knowledge, NGOs takes a distinctive perspective and give higher weightings of social criteria. For this reason, the district and sub-district level FD are rather interesting. Although FD primarily deals with suppressing the impacts of natural disturbances through afforestation/reforestation, it contributes to the socio-economic development of individuals through social forestry. As such, the ANOVA test does not indicate much difference except with NGOs (Table 5). Overall, social criteria receive less focus from the organizations unless it falls under their operational objectives.

#### 4.1.4. Economic

Economic criteria are ranked moderately by LGED, FD, and NGOs, while the remaining organizations ranked these as low. The local economy has been prioritized in the operational objectives of LGED and NGOs. These two organizations actively participate in building economic centers, reducing the poverty rate, providing micro-credit to the marginal farmers, and connecting remote areas with major markets. Although FD does not directly engage with economic development, they think that widespread poverty make people more vulnerable, 'this region is so low in elevation that a complete prohibition of flooding is nearly impossible. For this reason, an agriculture-based economy would not be helpful in diminishing poverty. We should focus more on economic development rather than only agriculture.' However, BWDB and DAE think otherwise. According to them, agriculture determines economic prosperity of the region. Although they acknowledged that some other dominant non-agricultural occupations exist, they characterized the occupations as indirectly or directly dependent on agriculture. In the words of DAE, 'the first victim of floods is usually the farmers. These farmers are dependent on agriculture and most often they do not have bank balance or any other financial support. Unless we can protect their economic means (aka agriculture), poverty cannot be eliminated from this region.' Such discrepancies in weighting have partly been observed through the ANOVA test (Table 6). In short, the organizations had differing opinions on the prioritization of economic and agricultural criteria. While some put more emphasis on economy than agriculture, others did the opposite.

#### 4.1.5. Natural

Among studied organizations, BWDB ranked natural criteria high, and the rest put it on moderate weighting; however, only the FD and NGOs have a significant difference with BWDB in weighting (Table 7). BWDB is responsible for hydrological operations including river dredging and construction of embankment. As a result, they are at the forefront of dealing the tidal fluctuations, river bank erosion, sedimentation and other natural phenomenon. BWDB acknowledges that low elevation, proximity to rivers/sea, and less tree cover can make certain parts of the region more vulnerable than others and the protective infrastructures can reduce vulnerability to some extent. Because of the operational objectives, BWDB ranked natural criteria higher than the other organizations, yet the importance of natural criteria is recognized by all.

**Table 5**
Differences in mean value between organizations in terms of social criteria weighting.

| Organizations | BWDB | LGED | DAE | FD | NGOs |
|---|---|---|---|---|---|
| BWDB | | −0.057 | −0.030 | −0.070 | −1.433** |
| LGED | | | 0.027 | −0.013 | −0.087 |
| DAE | | | | −0.040 | −0.113* |
| FD | | | | | −0.073 |
| ANOVA Diagnostic | *F*-statistics: 6.611** | | | | |
| Significance | *p*-value: '***' < 0.001, '**' < 0.01, '*' < 0.05 | | | | |

**Table 6**
Differences in mean value between organizations in terms of economic criteria weighting.

| Organizations | BWDB | LGED | DAE | FD | NGOs |
|---|---|---|---|---|---|
| BWDB | | −0.057 | 0.000 | −0.057 | −0.105** |
| LGED | | | 0.057 | 0.000 | −0.048 |
| DAE | | | | −0.057 | 0.105** |
| FD | | | | | −0.048 |
| ANOVA Diagnostic | *F*-statistics: 8.238** | | | | |
| Significance | *p*-value: '***' < 0.001, '**' < 0.01, '*' < 0.05 | | | | |

**Table 7**
Differences in mean value between organizations in terms of natural criteria weighting.

| Organizations | BWDB | LGED | DAE | FD | NGOs |
|---|---|---|---|---|---|
| BWDB | | 0.040 | 0.053* | 0.063** | 0.070** |
| LGED | | | 0.013 | 0.023 | 0.030 |
| DAE | | | | 0.010 | 0.017 |
| FD | | | | | 0.007 |
| ANOVA Diagnostic | *F*-statistics: 9.058** | | | | |
| Significance | *p*-value: '***' < 0.001, '**' < 0.01, '*' < 0.05 | | | | |

#### 4.1.6. Land use

Land use criteria are prioritized by BWDB and DAE as they are of primary concern by these organizations; however, there is no significant difference in prioritization by other organizations represented by the ANOVA test. BWDB aims to limit spread of soil salinity and maintain fertile lands, while DAE is concerned of expanding crop production area. Both of these organizations think that the region becomes more vulnerable when land use criteria are affected. Unlike district and sub-district level FD, the national level FD considers land use criteria as an important determinant and they think that greater forested or vegetated area ensures less vulnerability. Overall, all organizations put moderate to low weight on land use criteria depending on their operational objectives.

#### 4.1.7. Household characteristics

Household characteristics are ranked the lowest criteria by all the organizations. They admitted that the household characteristics are important for flood vulnerability; however, in their view, considering the biophysical and socio-economic criteria, household characteristics should get the least priority in vulnerability determination. As such, the ANOVA test shows that there are no significant differences among organizations in weighting household criteria. We think such weighting might have resulted from the fact that addressing household characteristics directly are beyond the scope of any organization's working domain.

As a whole, in the criteria weighting we observed no significant difference across levels of governance, but significant mean differences were found among organizations. The following figure shows a comparative average weighting of the criteria by the organizations (Fig. 6).

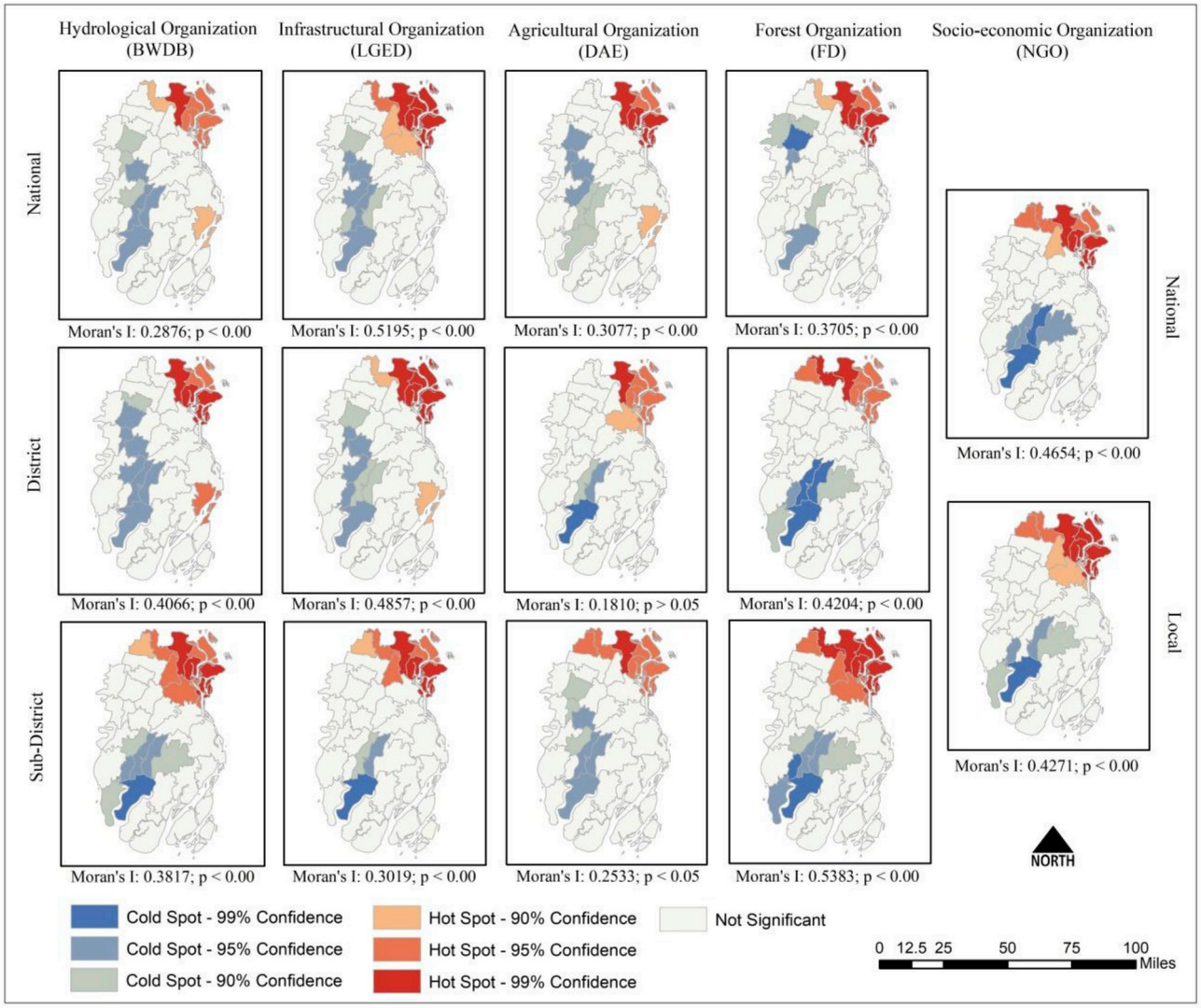


**Fig. 7.** Vulnerability hotspots identified by organizations at each sector and level.

Notably, mean weight values of different levels for each organization were considered. It is evident from Fig. 4 that the infrastructural and agricultural criteria received higher weight than other criteria by most of the organizations, while household characteristics received less attention. Clearly, infrastructure and agricultural are widely deemed important to reduce vulnerability to environmental stressors in the region. As an exception, the NGOs put relatively more weight in social and economic criteria, reflecting their working domain. The largest variances in weighting were particularly observed in the case of social, economic, and agricultural criteria.

### 4.2. Vulnerability hotspots

Global spatial autocorrelation (Moran's *I*) indicates that the vulnerability is not random, instead it is clustered over specific spatial scale, as one would expect. The hotspot analysis reveals that hot and cold spots are similar according to the framings of all organizations across all levels (Fig. 7). Based on their framings, Hizla, Muladi, and Mehendiganj sub-district in the northeastern part are vulnerability hotspots. These areas are characterized by high poverty, located very close to the *Meghna River*, and with few concrete-built houses and flood shelters. On the other hand, Betagi, Bamna, Kanthalia, Mirzaganj, and Rajapur in the south-central zone are vulnerability cold spots, because of greater distance from major rivers and sea, low poverty rate, greater number of shelters, and high literacy rate.

## 5. Discussion

Bangladesh's efforts in climate change mainstreaming have likely had an influence on the homogeneity in vulnerability framings. Nevertheless, discrepancies in the framings are noticeable in a few instances (Figs. 5 and 6). We suspect that such discrepancies are exhibited predominantly because of the sectoral policies and operational objectives of the organizations interviewed. For instance, operational objectives of DAE include ensuring food security through the provision of agricultural services. As such, DAE prioritizes agriculture over other criteria. Again, the sectoral policies of LGED and BWDB emphasize infrastructure related issues, and for this reason, these two organizations prioritize infrastructure while put less emphasis on social criteria. Similarly, NGOs have different agendas that are more specific to a particular issue (e.g. health, education) or constituencies (e.g. poor, vulnerable).

The ways in which organizational mandates affect framings and understanding of vulnerability is not surprising. Indeed, some scholars of geospatial analysis have posited that connotative features of landscape attributes should be considered explicitly in policy making. Bibby and Shepard (2004) to have three ontological dimensions: the constitutive – the objective condition and state of landscape features (e.g.,

elevation, water depth etc.), the agentive – referring to *how* actors interact with the landscape (e.g., deforestation), and the telic dimension – referring to the function of specific attributes in light of the organizational mandate and intention of a specific actor (see also discussion in Bojórquez-Tapia et al., 2011). Here we see evidence that the telic dimension of landscape features comes into play in differentiating the ways that the different sector organizations frame vulnerability, to some extent.

Discrepancies in vulnerability framings are sometimes considered to be of concern, as perhaps indicative of conflict or a potential for inefficiencies in management. In this case, we think that the discrepancy in vulnerability framings between NGOs and other organizations is not a matter of concern, but rather indicates how a diversity of agendas and sectoral roles can be complementary in adaptation. In particular, it appears that NGOs are filling the gaps in vulnerability management where government organizations are deficient (Batley and Rose, 2011). This complementary relationship with the government is represented through an active participation of NGOs in the socio-economic sector, specifically in education, health, and sanitation (Nair, 2011; Rose, 2011). Sansom (2011), for example, noted that limited resources of government organizations created an institutional space for NGOs in sanitation sector in Bangladesh and soon NGOs became a leading player in this sector. However, many NGOs are relatively narrow and limited in functionality. As such NGOs are playing vital roles in covering distinct foci not emphasized by the government in socio-economic sectors, some gaps might still persist.

Socio-politically, response to large scale environmental problems affect and are affected by multilevel governance, and homogeneity in understanding of the problem by stakeholders spanning across scale is desirable to addressing issue more effectively (Lemos and Agrawal, 2006). In our case, cross-level interactions among multilevel organizations played a critical role in the homogeneity of vulnerability framings. Cross-level interactions of information and knowledge flow are important as they offer insights on how to deal with multisectoral issues (Cash et al., 2006; Young, 2006; Termeer et al., 2010). Vertical (across different levels) and horizontal (across same level) linkages among organizations determine the information and knowledge flow among them (Young, 2002). In Bangladesh, vertical networks among sectoral organizations are well established in terms of information and knowledge flow. In this study, similar framings of vulnerability across sectors and levels of governance indicates greater information and knowledge flow which can potentially reduce the cross-scalar conflicts in managing limited resources (Adger et al., 2005, 2006). The reciprocity of the flow is maintained to some extent in this network; however, vertical relationship does not exist across sectors. To illustrate, the local level FD will not generally interact with higher level BWDB. On the other hand, the sub-national level horizontal interactions are quite frequent, but national level horizontal interaction is limited. At the sub-national level, the district and sub-district administrations hold a meeting in every 2–4 months regarding the actions undertaken in different sectors such as, agriculture, forest etc. This meeting is attended by all major organizations engaged in vulnerability management. In this meeting, these organizations share their action updates and requirements from other organizations. This meeting also aims to resolve confusions, conflicts, and misunderstandings among organizations, if any. Furthermore, these organizations are also connected with each other through need-based informal interactions. In case of any immediate requirement at the sub-national level, an organization can contact the another directly and resolve minor issues. For example, if the sub-national level FD encounters problems in tree plantation over the embankments, they contact the same level BWDB officials to discuss and resolve their concerns. Again, if the BWDB faces difficulties in constructing embankments because of local political dynamics, they can seek law and order assistance from district or sub-district administrations. This structure of strong sectoral vertical linkages and moderately-strong horizontal cross-sector linkages may represent a particularly robust configuration for adaptation governance. It provides consistency in sectoral policy, and allows generic principles regarding adaptation to permeate from the national level to local level actors. The strong horizontal linkages provide a capacity for refinement, precision and coordination necessary in the operationalization of such generic principles in specific social and environmental contexts. Due to these frequent interactions, they often have a good understanding of each other's understanding of vulnerability. Furthermore, our interviews with the organization officials reveals that the government promotes discussion on climate change impacts at different levels of governance, provides documentation and training to the officials, and appreciates the inclusion of climate change in the short-term and medium-term projects. Also, the government encourages NGOs to play active roles in enhancing local adaptive capacity, and thus channels 10% of the $170 million Bangladesh Climate Change Resilience Fund to them (GED, 2015). We suspect that such promotion of cross-level interactions contributes to the alignment of the vulnerability framings of these organizations.

While similar understanding of vulnerability offers insights on dealing with complex multisectoral issues, it can also raise some concerns such as what has been called the ‘coordination dilemma’ and ‘work scope overlapping’ (Termeer et al., 2010). Coordination dilemma occurs when coordinating among a large number of stakeholders demands significant time and resources, and overlapping happens when two or more organizations address the same issue similarly. Such overlapping becomes evident in coastal Bangladesh when LGED, in one instance, planted trees in their project areas whereas it was supposed to be done by FD with a lower expenditure.

Overall, the alignment in vulnerability framing indicates that the leading organizations working in different sectors understand vulnerability in similar homogeneous way. Such similar understanding is important for avoiding fragmented development initiatives and undertaking vulnerability reduction measures for those who need it the most. We found that the locations of adaptation projects by the leading organizations correspond to their vulnerability framings. We obtained the details of currently running projects from their websites and found that the sub-districts of *Barisal* and *Patuakhali* districts have higher climate adaptation related projects running now than other districts. In *Barisal*, each sub-district has around 12 running projects on an average, and in *Patuakhali*, the number is 15. Relatively less vulnerable *Pirojpur* and *Barguna* districts have 10 running projects in each sub-district, and the sub-districts under *Jhalkathi* district have only four projects. We think that the vulnerability framing might not directly contribute in developing these projects, but it might influence these undertakings circuitously. In this way, on one hand, homogeneity in framings assists the decision makers to undertake investment decisions and effective adaptation actions, and on the other hand, diversity in the framing of FD and NGO represent emphasis on different sectors.

## 6. Conclusion

As discussed in this paper, vulnerability framing has been described as a process by which stakeholders construct meaning to understanding the consequences of particular event or occurrence. Although vulnerability to climate change is intuitively framed one way or another, it plays an important role in research, policy development and policy implementation. Framing allows certain questions to be asked repeatedly and with emphasis at the cost of other equally important ones. Our study contributes to multilevel vulnerability research through an analysis of vulnerability framings at different sectors and levels of governance. We developed a spatial MCDA approach by creating a key-informant led composite vulnerability index and identifying vulnerability hotspots. Overall, the study found a significant alignment in the vulnerability framings of leading organizations operating at the forefront of climate vulnerability management in coastal Bangladesh. However, the NGOs we consulted showed a significant difference in

framing, primarily because of the difference in their working domain, mandates and sectoral priority. In essence, for NGO, framing is truly social process that relates to the way individual (or household) interact in social groups. Since vulnerability framing, especially from social science perspective, is embedded in, and part of, social, cultural and political processes, it has the potential to determine certain pathways to climate vulnerability and its response. For this reason, stakeholders engaged in managing vulnerability are able to reflect on preconceived framing and engaged in the development of shared framing of vulnerability.

Most of the organizations, irrespective of sectors or levels, acknowledge the importance of infrastructure and agriculture in reducing vulnerability in the region. Such similar understanding of the organizations would minimize resistance in decision making, actuate information and resource flow, and thus be facilitative to efficient adaptation governance across coastal areas. We also observed some minor misalignments across the sectors. These mismatches in framing are likely the result of different operational objectives which indicate diversity in understanding and, ultimately, a more complete governance of adaptation and vulnerability in the region. However, while similar understanding of vulnerability indicate a priority on infrastructural and agricultural criteria, it is probable that other criteria are less emphasized, if not ignored, potentially to the detriment of addressing vulnerability effectively. The implications of such neglect could be demonstrated as a reduction of exposure with no substantial impact on adaptive capacity or sensitivity. The research presented here indicates that it is not enough to have vulnerability assessments and adaptation plans in place; it is also important to evaluate the assumptions about the determinants of vulnerability held by different agencies, and how these assumptions manifest in spatial understanding of vulnerability and adaptation investments. Vulnerability has both subjective and objective dimensions; by making the subjective dimensions explicit, the governance of vulnerability can be made more effective. By investigating the framing of vulnerability across scale, this paper reveals theories, concepts, and approaches as well as their proliferation through professional training and sectoral approaches.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2019.01.020.

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